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ELECTROMAGNETIC VIBRATION ENERGY HARVESTER USING LABVIEW

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ABSTRACT

The electromagnetic energy harvester in current scenario, has received an importance in harvesting the energy dissipated due to vibration in macro scale. The proposed work is developed in the motive of harvesting the energy from vibration using a linear arrangement of NdFeB magnets. It is a specific arrangement of electromagnets that concentrates the magnetic fields. The relative motion between the magnets and coil tends to develop an emf in it. The output power of harvester with vibration in linear arrangement of NdFeB magnets is found to be greater than those with permanent magnet. The microcontroller accept the analog voltage signals of mechanical setup and is able to generate output waveform for voltage depending upon the maximum vibration speed and depend upon the coil resistance current is measured using labVIEW**.**

KEYWORDS: Electromagnetic Harvester, Vibration Energy Harvester, Labview, Microcontroller

INTRODUCTION

Energy harvesting also known as power harvesting or energy scavenging is the process by which energy is derived from external sources, captured, and stored for small, wireless autonomous devices, like those used in wearable electronics and wireless sensor networks.

Energy harvesters provide a very small amount of power for low-energy electronics. While the input fuel to some large-scale generation costs money (oil, coal, etc.), the energy source for energy harvesters is present as ambient background and is free. For example, temperature gradients exist from the operation of a combustion engine and in urban areas, there is a large amount of electromagnetic energy in the environment because of radio and television broadcasting.

The use of electromagnetic damper in a tuned mass damper scheme produces the most available energy. Electromagnetic device are able to convert kinetic energy into electricity. The voltage is produced between two ends by movement of magnetic field. The world has become completely dependent of electric fields. Everything use on a daily basis is directly related to electromagnetic fields ranging from radios to cell phones to satellite TV and even to light in general. Through the combination of electromagnetic fields and the typical land phone, cell phone is created which utilizes radio waves created by electromagnetic fields, to transmit data across the world in a fraction of a seconds.

SYSTEM ARCHITECTURE

Electromagnetic Vibration Energy Harvesting

The block diagram of the developed system is shown in Figure 1. The block diagram consists of mechanical part, electrical part and displaying part.

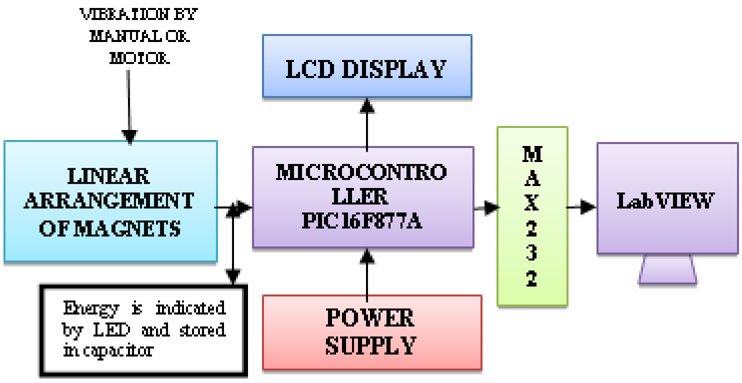

Figure 1: Block Diagram

The Mechanical part consist of linear arrangement of NdFeB magnets by giving vibration in which move in relative motion between magnets and coil used to harvest the energy. The electrical part consist of PIC microcontroller and MAX232 used to control the ADC signal from the output of mechanical setup. The displaying part used to display the output waveforms in LabVIEW.

Materials Used in Mechanical Part

- NdFeB magnets
- Acrylic sheet
- SS screw rod
- 12V DC Gear motor

Neodymium Magnets

A neodymium magnet (NdFeB, NIB or Neo), the most widely used type of rare-earth magnet made from an alloy of neodymium, iron and boron. They have replaced other types of magnet in the many applications such as motors in cordless tools, hard disk drives and magnetic fasteners. They have the highest magnetic field strength and have a higher coercivity.

Acrylic Sheet

Acrylic looks like glass, but has 10-20 times the impact resistance for the same size. It exhibits clarity, transparency and it can be easily mold. The main issue with acrylic is cloudiness caused by abrasion.

Stainless Steel Screw Rod

SS SCREW ROD is relatively long rod that is threaded, that may extend along the complete length of the rod. They are designed to be used in tension.

Volt Dc Gear Motor

It can be used in variety of robotics application and it is available with wide range of rpm.

Materials Used in Electrical Part

- PIC microcontroller
- Usb to serial port cable
- Voltage regulator
- MAX232
- LCD

PIC Microcontroller

PIC is initially developed by General Instrument's Microelectronics Division and then later developed by Microchip Technology. PIC family is a modified version of Harvard architecture. The PIC stands for "Peripheral Interface Controller". The output of analog signal is given to the microcontroller PIC16F77A. It is suited for sensing the analog values and sends it to the slave microcontroller. Since the analog values has to be monitored continuously and so there will be need of inbuilt ADC module. Hence, to reduce the system complexity by making use of inbuilt ADC of PIC microcontroller. It has an inbuilt 8 channel analog to digital converter. It is a 16 bit address and 10 bit resolution. The limitation of this PIC is it does not have an inbuilt local oscillator but this is not an issue in my project.

MAX 232

The MAX232 is initially created by MAXIM INTEGRATED PRODUCTS. It converts signals from an RS-232 serial port to signals suitable for use in TTL compatible digital logic circuits. The MAX232 is a duplex driver/receiver.

LCD

A liquid crystal display (LCD) is a display system that uses the light modulating properties of liquid crystals (LCs).These systems are easy to read. LCDs do not emit light directly.

USB TO SERIAL PORT CABLE

A USB adapter is a type of protocol converter which is used for converting USB data signals to and from other communications standards. USB adaptors are used to convert USB data to standard serial port data and vice versa. Data signals are converted to RS232, RS485 or any other serial data.

Voltage Regulator

A voltage regulator is used to maintain a constant voltage level. A voltage regulator may be a simple feed-forward design or may includenegative feedback control loops. It may use an electromechanical mechanism or electronic components. Depending on the design, it is used to regulate one or more AC or DC voltages.

MECHANICAL PART IMPLEMENTATION

The prototype is made by using total number of six Neodymium magnets (NdFeB) and acrylic sheet are cut in the same size of magnet that it is used as core in between the magnets. The magnets and cores are skewered and glued on a non-magnetic stainless steel shaft. The outer and the inner diameters of each magnet are 27mm and 15 mm and thickness is 5mm. The coil is used with 1mm thickness and 3000 turns with 100Ω resistance.

Table 1

Magnet and Core Arrangements	Turns of Coil	Output Voltage
	1000 TURNS s	2 VOLTS
	3000 TURNS 	6 VOLTS

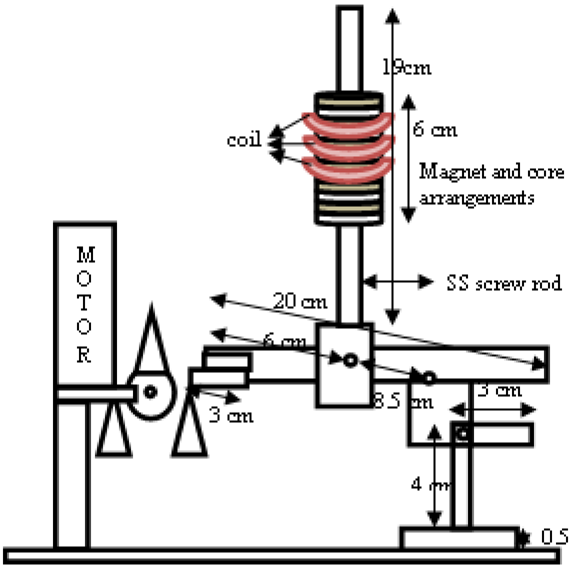

Figure 1: Design of Mechanical Part

In prototype design, When vibration is given either manually or motor that the magnet move relatively in linear movement with each other inside the coil, which is used to convert mechanical energy to electrical energy in the form of analog voltage. The design of mechanical part is shown in figure 1

Analysis of Testing

Table 1 Magnet, Core, Coil arrangements and Output

The magnets and core arrangements are set and the tested using coil wound by 1000 and 3000 turns of coil are shown in table1.

ELECTRICAL PART IMPLEMENTATION

The output of analog signal is given to the microcontroller PIC16F77A. It is suited for sensing the analog values and sends it to the slave microcontroller. Since the analog values has to be monitored continuously and so there will be need of inbuilt ADC module. Hence, to reduce the system complexity by making use of inbuilt ADC of PIC microcontroller. It has an inbuilt 8 channel analog to digital converter. It is a 16 bit address and 10 bit resolution. The limitation of this PIC is it does not have an inbuilt local oscillator but this is not an issue in my project. LCD is interfaced with microcontroller which is used to display that which the signals are transmitted. Coding for interfacing PIC with LCD should be written.

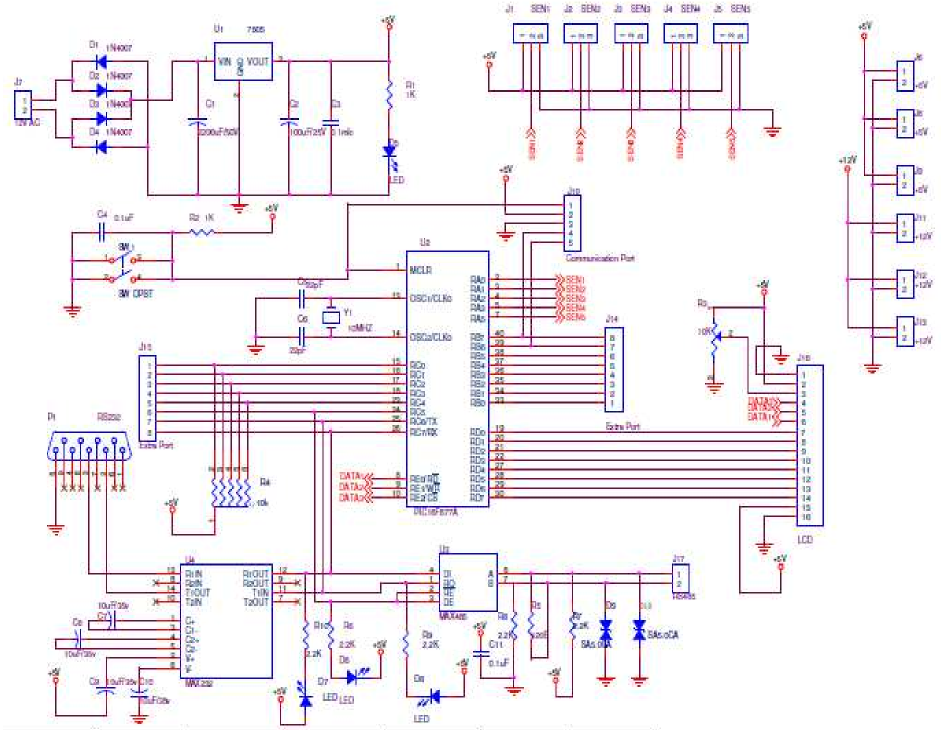

Figure 2: Implementation of Electrical Part

The output of analog signal is given to the microcontroller PIC16F77A. It is suited for sensing the analog values and sends it to the slave microcontroller. Since the analog values has to be monitored continuously and so there will be need of inbuilt ADC module. Hence, to reduce the system complexity by making use of inbuilt ADC of PIC microcontroller. It has an inbuilt 8 channel analog to digital converter. It is a 16 bit address and 10 bit resolution. The limitation of this PIC is it does not have an inbuilt local oscillator but this is not an issue in my project. LCD is interfaced with microcontroller which is used to display that which the signals are transmitted. Coding for interfacing PIC with LCD should be written.

SOFTWARE UNIT

Software's are to cull the coding of the desired application for the corresponding embedded system for coding and labVIEW for output voltage response.

MPLAB

The PIC16F877A microcontroller is founded by Microchip and they had designed a compiler to develop user-defined programs for different kind of applications which is namely called as MPLAB Compiler. Assembly and C programming languages can be used with MPLAB IDE v8. It is also a cross compiler which can also be used other kind of architectures. For PIC series of controllers only MPLAB compiler is used. In this project we are using PIC16F877A Microcontroller and for that controller Microchip developed a compatible and user-friendly compiler for programming which is named MPLAB or hi-tech compiler.

Lab VIEW

LabVIEW (Laboratory Virtual Instrument Engineering Workbench) version 2010 is a graphical programming language that uses icons instead of lines of text to create applications. In contrast to text-based programming languages, where instructions determine the order of program execution, labVIEW uses dataflow programming, in which the flow of data through the nodes on the block diagram determines the execution order of the VIs and functions. VIs, or virtual instruments, is LabVIEW programs that imitate physical instruments. Front panel serves as the user interface. Block diagram contains the graphical source code that defines the functionality of the VI. Icon and connector pane identifies the interface to the VI so that the user can use the VI in another VI. User can build an interface by using a set of tools and objects. The user interface is known as the front panel. The user can add code using graphical representations of functions to control the front panel objects.

Lab VIEW programs are called virtual instruments, or VIs, because their appearance and operation imitate physical instruments, such as oscilloscopes and millimeters. Every VI uses functions that manipulate input from the user interface or other sources and display that information or move it to other files or other computers. LabVIEW has evolved over a period of years and now it’s a one powerful tool for engineers and industrialists. In university environments, it is a standard instructional tool for introductory and advanced courses in engineering and science. Unlike MATLAB which uses mathematical models and systems, LabVIEW provides more sophisticated and user friendly environment. Graphical modeling, real time interfaces, and simulation are the key features.

VIRTUAL PROGRAMMING OF ENERGY HARVESTING USING LabVIEW

LabVIEW 2010 version is used for virtual programming in which figure 3 shows the block diagram panel of virtual program for the electromagnetic vibration energy harvester. In this VI program while loop is used along with formula node, stacked sequence structure and case structure.

VISA serial port is used to initialize the serial port for specified settings:

- **Enable Termination Char** prepares the serial device to recognize termination char. If **TRUE** (default), it is set to recognize the termination character. If **FALSE**, it is set to 0 (None) and the serial device does not recognize the termination char.
- **Timeout** specifies the time in milliseconds, for the write and read operations. The default is 10000.
- **Baud rate** is the rate of transmission. The default is 9600.
- **Data bits** is the number of bits in the incoming data. The value of **data bits** is between five and eight. The default

value is 8.

- **Parity** specifies the parity used for every frame to be transmitted or received.
- **Stop bits** specifies the number of stop bits used to indicate the end of a frame.

In this stacked sequence structure is used for setting delay and to get accurate energy harvesting waveform. Case structure is used for VISA write and VISA read which is used to acquire the signal to write and read the buffer.

The output of Read buffer is given to string-byte; where the ASCII code denoted as bytes and it forms an array then it goes to cluster where it is unbundled by name which one of the value is given to formula node there it is used to produce output waveform in ADC and voltage by adding the lower bit and higher bit values by using formula.

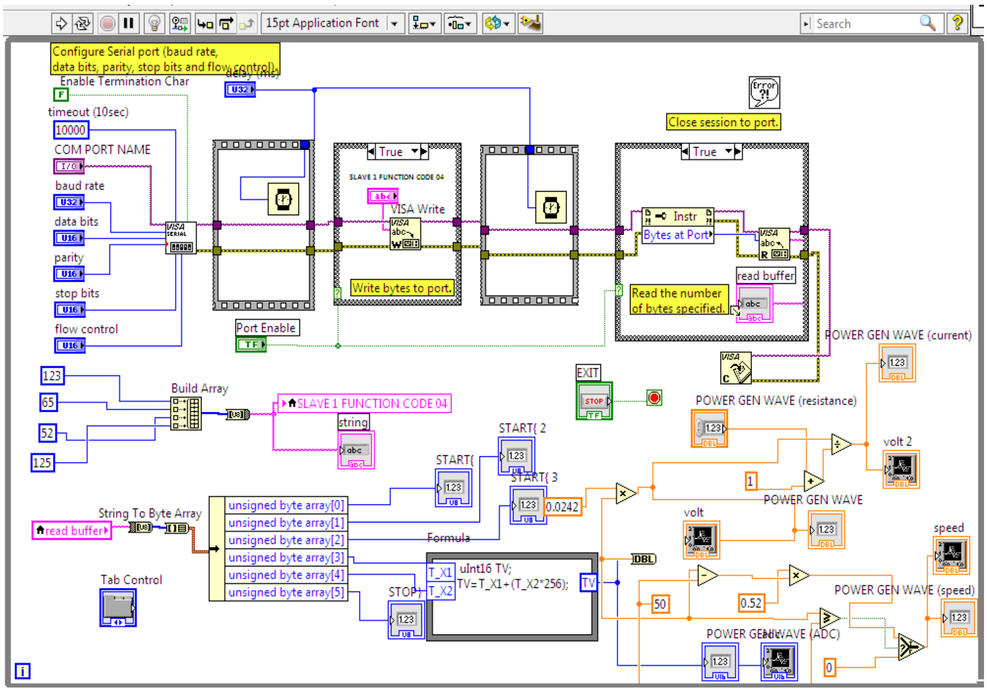

Figure 3: Virtual Program For Electromagnetic Vibration Energy Harvester

Formula node is used to calculate the operation;

Uln16Tv;

$Tv=T\_x_1+(T\_x_2*256)$; (6.1)

Where,

T_x_1=lower bit value

T_x_2=higher bit value

Multiplying by 256 due to 16 Bit

One output from formula node is ADC waveform and to get output voltage by multiplying the ADC output with 0.0242 due to 5 voltage and 8 bit ADC. To get current output waveform; the output voltage is to be divided by 100Ω which is the value of coil resistance.

Due to tab control used in block diagram of LabVIEW, there will be 2 tabs appear in front panel. One tab is used

to set the serial setting and another tab is used to display the output waveforms.

Figure 4 shows serial port of electromagnetic vibration energy harvester; the terminals what I have created in LabVIEW of block diagram will be appeared in front panel. It is used to set the communication port name in which serial port is connected and it is also used to set baud rate(9600), data bits(8), parity, delay(100) and flow control. String is used to check the data to be read in the read buffer.

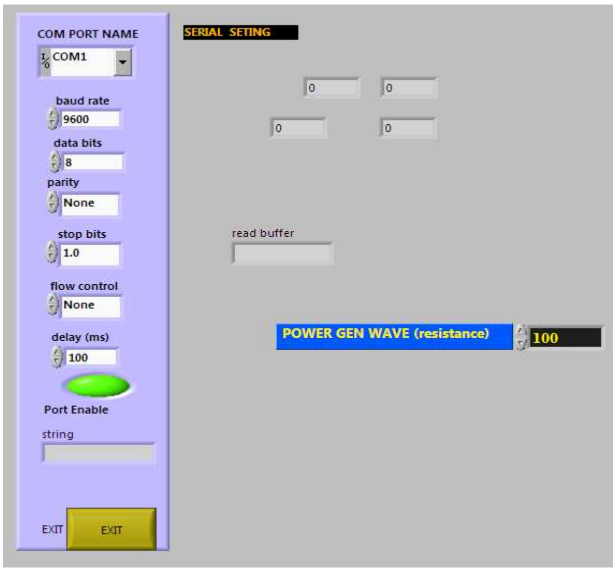

Figure 4: Front Panel Serial Port of Electromagnetic Vibration Energy Harvester

The main objective of this work is to design LabVIEW based energy harvest and control system for simulating the ADC, voltage response, speed and current for giving vibration in a linear arrangement of magnets inside the coil used to harvest the energy which is implemented successfully.

RESULT OF ENERGY HARVESTER

Figure 5 and 6 refers the front panel for electromagnetic vibration energy harvester for the output waveforms. The waveform chart is used to indicate the ADC, voltage, speed and current response. As vibration which is given in a linear arrangement of magnets, magnetic flux is cut by the coil and hence an emf is induced.

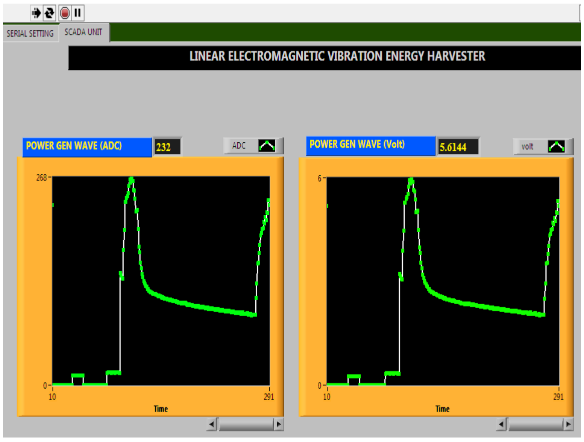

Figure 5: Output Waveforms for ADC and Voltage

For the maximum amount of vibration, linear arrangement of NdFeB magnets and coil which harvest the energy

in waveform chart as maximum ADC as 232, output voltage response of 5.6144 volts, speed as 100.3 and current as 0.058223 in the waveform chart of front panel.

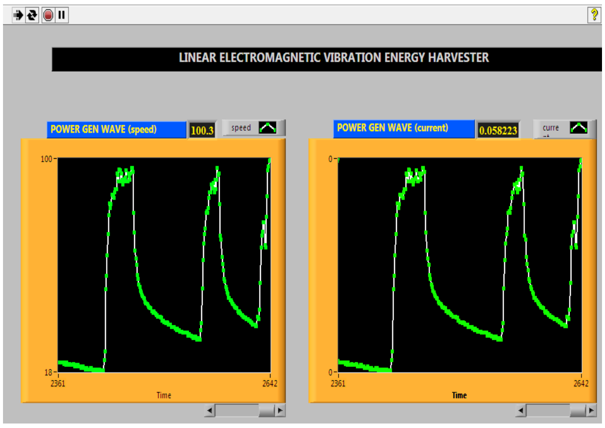

Figure 6: Output Waveforms for Speed and Current

The main objective of this work is to design LabVIEW based energy harvest and control system for simulating the voltage, ADC, voltage and current response for given vibration in a linear arrangement of magnets and coil which is implemented successfully. The result shows that the LabVIEW based controller is easy to design and also produces better output than conventional controllers.

Table 2: Comparison between Manual and Motor Vibration Output

Mode	Analog Value	Speed	Voltage (Volts)	Current (Amps)
MANUAL	232	100.3	5.6144	0.058223
12V DC GEAR MOTOR	167	55.12	4.04	0.0373

Table 2 shows the output between vibration by manual and motor. Figure 7 shows the prototype of linear arrangement of electromagnetic vibration energy harvester.

Figure 7: Prototype of Electromagnetic Vibration Energy Harvester

CONCLUSIONS

The venture intention at describing the design procedure of electromagnetic vibration energy harvester and is simulated by interfacing with labVIEW. The various voltages obtained for various levels of vibrations are visualized using labVIEW. The electromagnetic vibration energy harvester is implemented in real time. For the maximum given vibration, the output energy obtained is 5.61 volts.

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